Towards Real-time Quarter-hour Monitoring of the Urban Thermal Environment at Sharpened Spatial Resolution

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The structure of this Presentation

1. Introduction

2. System Presentation

3. Exploitation

4. Now & Tomorrow
Surface Urban Heat Island (SUHI)

Late Afternoon Temperature °C

- Rural
- Suburban Residential
- Commercial
- Downtown
- Urban Residential
- Park
- Suburban Residential
- Rural Farmland

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Basic Features of SUHIs

- Intensity
- Spatial Extent
- Orientation
- Centroid

London LST, August 2003

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MSG 2 - SEVIRI

• Geostationary Satellite
• 4 VNIR and 8 IR Spectral Bands
• 3-5 km Spatial Resolution
• 15 min Temporal Resolution
Presenting

THE SYSTEM
Why is this system important?

• This system can provide LST data that combine high temporal and spatial resolution for monitoring the SUHI effect.
The Workflow

- Processing on Earth Disk Level
  - TIGR Dataset
  - 4V/OP
  - Inverse Model
  - MOD11A2

- Real-time SEVIRI Image Acquisition
- SEVIRI Data
- CMa Calculation
- Cloud-free SEVIRI Data
- LST Retrieval
- LST (3-5 km / 15 min)

- NCEP GFS

- Processing on City Level
  - LST Downscaling (1 km / 15 min)
  - Online City Database
  - MOD13A2, MOD11A2, SRTM, GlobCover

- MODIS Global Urban Extent c2001 Maps

City Extraction

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Abstract—Although Earth observation data have been used in urban thermal applications extensively, these studies are often limited by the choices made in data selection, i.e., either using data with high spatial and low temporal resolution, or data with high temporal and low spatial resolution. The challenge of advancing the low spatial (3-5 km) resolution of geostationary land surface temperature (LST) images to 1 km—while maintaining the excellent temporal resolution of 15 min—is approached in this letter. The downscaling was performed using different advanced regression algorithms, such as support vector regression machines, neural networks, and regression trees, and its performance was improved using gradient boosting. The methodologies were tested on Meteosat Second Generation (MSG) SEVIRI LST images over an area of 19,600 km² centered in Athens, Greece. The output 1-km downscaled LST images were assessed against coincident LST maps derived from the thermal infrared imagery of the Moderate Resolution Imaging Spectroradiometer, the Advanced Very High Resolution Radiometer, and the Advanced Along Track Scanning Radiometer. The results showed that support vector machines coupled with gradient boosting proved to be a robust high-performance methodology reaching correlation coefficients from 0.69 to 0.81 when compared with the other satellite-derived LST maps.

Index Terms—Boosting, Earth observing system, support vector regression machines (SVR), temperature measurement, urban areas.

I. INTRODUCTION

A S HUMANS alter the characteristics of the natural landscape in the urbanization process, they affect and impact local energy exchanges that take place within the atmospheric boundary layer. The impact may be of a local, a regional, or a global scale, depending on the size of the area affected.

These measurements provide essential data for analyzing urban thermal landscape patterns and their relationship with surface biophysical characteristics, assessing the surface urban heat island (SUHI) effect and relating LST with surface heat fluxes for characterizing landscape properties, patterns, and processes [2]. If the advantage of time-sequential observations of satellite sensors (and daytime and nighttime imaging) is considered, remote sensing data have great potential for studying the urban surface energy budget and the spatial pattern and temporal dynamics of urban thermal landscapes [2].
Enhanced Spatial Resolution

Casablanca

Cairo
Enhanced Temporal Resolution

Data Acquisition: March 13, 2014
First Results

Performance Assessment* [Ongoing]

At 3-5 km – Comparison with LandSAF LST data

<table>
<thead>
<tr>
<th>City</th>
<th>Mean Difference</th>
<th>STDDEV</th>
<th>RMSE</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Athens</td>
<td>+0.43°C</td>
<td>1.89</td>
<td>2.15</td>
<td>71.1%</td>
</tr>
<tr>
<td>Istanbul</td>
<td>+0.42°C</td>
<td>1.68</td>
<td>1.78</td>
<td>70.0%</td>
</tr>
</tbody>
</table>

At 1 km – Comparison with MOD11A1 LST data [Athens]

<table>
<thead>
<tr>
<th>Mean Difference</th>
<th>STDDEV</th>
<th>RMSE</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>+0.26°C</td>
<td>1.88</td>
<td>2.22</td>
<td>65.3%</td>
</tr>
</tbody>
</table>

[*The performance assessment was carried out for the city of Athens, Greece and/or Istanbul, Turkey for April and/or May 2014.]*
Presenting some of

THE NUMEROUS APPLICATIONS
What this system offers?

- The optimized exploitation of the data
- Tailoring for different purposes/applications/end-users.
Iphigenia Keramitsoglou. 2013. Investigations of the diurnal thermal behavior of Athens, Greece, by statistical downscaling of land surface temperature images and pattern analysis,

Heat wave hazard classification and risk assessment using artificial intelligence fuzzy logic

Iphigenia Keramitsoglou · Chris T. Kiranoudis · Bino Maiheu · Koen De Ridder · Ioannis A. Daglis · Paolo Manunta · Marc Paganini
Cooling Degree Hours - CDH

$T_b \ 20^\circ C$

$T_b \ 21^\circ C$

$T_b \ 22^\circ C$

$T_b \ 23^\circ C$

$T_b \ 24^\circ C$

CDH
Green Vehicle Routing

- urban CO$_2$ domes
- SUHI

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ADVANTAGES

- Real Time
- Enhanced Spatial Resolution - 1 km
- Temporal Resolution - 15 min
- Large Urban Coverage – Earth Disk 117 cities
To find more details visit:
beyond-eocenter.eu/  @ URBAN ENVIRONMENT

National Observatory of Athens  |  NOA/IAASARS
New Service for Quarter-hour Monitoring of Urban Temperatures at 1 km from Space